

Implementation of Precision Verification Solvents on the External Tank

Background

- 1,1,2-Trichloro-1,2,2-Trifluoroethane (CFC 113) was phased out of production and cannot be purchased from the original manufacturer after Dec'95
- CFC 113 can be used until depleted from stock.
- MSFC-SPEC-164 is governing document that requires use of CFC 113, 1,1,2-Trichlorethylene (TCE), or 1,1,1-Trichloroethane (TCA) or alternative solvents if approved by MSFC to verify Non Volatile Residue(NVR) and particulates.
- All solvents that are used for verification must be approved in JSC, SE-S-0073 by KSC, JSC, Boeing-Rockwell and Rocketdyne divisions, MSFC etc.,.

NASB-36200
7N-16-CR
249127

Solvent Usages

- TCE used at Michoud Assembly Facility (MAF) since the early '60s to verify NVR/particulates on the liquid oxygen (LOX) tank and water used to verify liquid hydrogen(LH2) tank,
- TCE has a threshold limit value (TLV) of 50 ppm and has been handled safely during the interval.
- CFC 113 used to verify smaller parts, e.g., 20 foot feedlines, manhole covers, nuts/bolts, etc.

LOCKHEED MARTIN 

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TCE Reduction

- TCE sprayed inside the entire LOX tank surfaces ($\approx 8000 \text{ ft}^2$) to verify NVR/ particulate
- TCE usage about 5,000gals/year
- Local pollution laws allow for 700 pounds (56 gallons) yearly emissions
- Comparative studies done over five LOX tanks to compare reduced usage (3 gallons/100 ft^2) of TCE with full flow values of TCE
- Reduced flow TCE gives comparable values and is implemented (1994).
- Further on-going work with alternate verification solvents continues.

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Solvent Replacement Studies

- 1991-1994 Review of all commercially available solvents narrows the choice down to TCE and isopropyl alcohol (IPA)
- TCE and isopropyl alcohol (IPA) qualified in late 1994 for general usage on the ET. No issues with material compatibility.

Note 1: Comments from the technical community require that IPA be verified as removed after verification as IPA is NOT LOX compatible.

Note 2: Approval within the technical community to amend the paper work takes 1 year.

- June 1995 two things occur,
 - 1) As implementation progresses to implement IPA/TCE at MAF, EPA approves 3,3-Dichloro-1,1,1,2,2-pentafluoropropane (45%)/1,3-dichloro-1,1,2,2,3-pentafluoropropane (55%), HCFC 225, as an acceptable solvent for precision cleaning
- All toxicological and exposure data for HCFC 225 complete. TLV limit is 50 ppm
- 2) KSC issues final report that a water/ surfactant solution can be used to verify LH2 systems. The solution contains a surfactant (DuPont Zonyl FSN® at 25 ppm in demineralized water)

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Implementation

- Change of direction occurs and a decision is made to qualify HCFC 225 and water /surfactant.
- HCFC-225 passed the cleaning test and the material compatibility tests for flight hardware.
- Water /surfactant testing from KSC accepted as valid, e.g., materials compatibility, solution performance, etc.

Note 3: Due to the interaction of the NOET team from MSFC with other shuttle contractors, testing was minimized because of KSC involvement on the team.

- Documentation changed for approval of HCFC 225 and water / surfactant solution (LH2 verification only).

Note 4: Based on pre-coordination of effort, approval takes 4 months from submittal

MAF decides to implement HCFC 225 only for all uses

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Problems Occurring During Implementation

- In retrofitting the existing CFC 113 system, it is discovered that some internal fitting are Buna N which is attacked by HCFC 225. Concern is raised over other non flight tooling that cannot be taken apart or that are old in which there are no substitute parts available.
- Re-thinking at MAF about usage of HCFC 225 on non-flight parts and the concern about the TLV limit of 50 ppm lead to the decision to use water surfactant on LH2 parts/tooling that have no faying surfaces HCFC 225 on only LO2 parts/tooling and the possibility of using GN2 for testing of pressure gauges.
- A separate water /surfactant system is constructed and the existing CFC 113 facility retrofitted for use with HCFC 225 with modifications to handle the solvent.

Note 5: During the validation of water /surfactant, tooling problems are noted such as the puddling of water so that the dryness of the part could not be verified. Tooling was modified so that there is no standing water within the tool.

- As of this paper, HCFC is qualified for all LOX/LH2 parts and water surfactants for LH2 parts.

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Future Work

- To fully assess the safety of HCFC 225, personal protective gear is being worn and the solvent emissions measured to ascertain the need for required protective gear.
- HCFC 225 will be implemented for use to verify the LOX tank
- Ongoing development of alternative solvents (Vertrel MCA) or methods (high pressure water) to minimize exposure to hazardous chemicals.